

We claim:

1. A method for fabricating a light generating die with fiducials from a multi-layered structure comprising a substrate and an etch-stop layer, the
5 method comprising the steps of:
 - (1) depositing an etch-stop layer over said structure;
 - (2) etching through said etch-stop layer and said structure to form an active mesa and a fiducial, said fiducial comprising at least one feature positioned in a known spatial relation relative to said mesa;
 - 10 (3) regrowing one or more layers on said structure; and
 - (4) selectively etching a portion of said regrowth layer to expose said fiducial.
2. The method of claim 1 wherein said fiducial is a mechanical
15 fiducial comprising a second mesa defining an alignment notch having a first surface along a top surface of said etch-stop layer of said second mesa and a second surface along a side surface of said second mesa.
3. A method for mounting said die of claim 2 to a substrate, said
20 method further comprising the steps of:
 - (5) placing said die on said substrate;

(6) moving said die to cause said second surface to abut a mating surface on said die, said mating surface positioned so as to cause said die to be in a desired position on said substrate in at least a first direction; and

(7) attaching said die to said substrate.

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4. The method of claim 3 wherein step (6) comprises moving said die on said substrate so that said first surface of said die registers with a mating surface on said substrate, said mating surface positioned so as to cause said die to be in a desired position on said substrate in at least a second direction.

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5. The method of claim 1 wherein said fiducial is a visual fiducial comprising a void in said multilayer structure having visible features in at least two dimensions.

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6. A method for mounting a die fabricated as set forth in claim 5 to a substrate, said method further comprising the steps of:

(8) optically detecting said visual fiducial on said die;

(9) optically detecting a mating visual fiducial on said substrate positioned on said substrate such that, when said visual fiducial on said die
20 overlays said mating visual fiducial on said substrate, said die is in a desired position on said substrate;

(10) optically aligning said fiducial on said die with said mating fiducial on said substrate so that they overlay each other; and

(11) attaching said die to said substrate.

5 7. The method of claim 5 further comprising the step of:

(12) forming metal pads on said die using said visual fiducial as an optical indicia for positioning of said metal pads on said die.

8. The method of claim 7 further comprising the step of :

10 (13) placing a wettable material on said metal pads.

9. A method for mounting a die fabricated as set forth in claim 7 to a substrate having pads positioned to mate with said pads on said die, said method further comprising the steps of:

15 (14) forming a wettable material on at least one of said pads on said die and said pads on said substrate;

(15) placing said die on said substrate such that each said pad on said die roughly overlays said mating pad on said substrate; and

(16) melting said wettable material, whereby said die is brought into fine
20 alignment with said mating pad on said substrate via surface tension of said wettable material.

10. The method of claim 5 wherein said visual fiducial comprises at least two distinct visual fiducials, each having visible features in at least two dimensions.

5 11. The method of claim 10 further comprising the step of:
(17) placing a wettable material in said voids on said die.

12. The method of claim 10 further comprising the steps of:
(18) forming metal pads in said voids.

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13. The method of claim 11 wherein step (17) comprises forming metal pads in said voids and subsequently placing said wettable material on said metal pads.

15 14. A method for mounting a die fabricated as set forth in claim 11 to a substrate having pads positioned to mate with said voids on said die, said method further comprising the steps of:

(19) placing said die on said substrate such that each said void on said die roughly overlays said mating pad on said substrate; and

20 (20) melting said wettable material, whereby each of said pads on said die is brought into fine alignment with said mating pad on said substrate via surface tension of said wettable material.

15. A method for mounting a die fabricated as set forth in claim 12 to a substrate having pads positioned to mate with said voids on said die and a wettable material on said pads, said method further comprising the steps of:

(21) placing said die on said substrate such that each said void on said die roughly overlays said mating pad on said substrate; and

(22) melting said wettable material, whereby each of said pads on said die are brought into fine alignment with said mating pad on said substrate via surface tension of said wettable material.

10 16. A method for mounting a die fabricated as set forth in claim 13 to a substrate having metal pads positioned to mate with said voids on said die, said method further comprising the steps of:

(23) placing said die on said substrate such that each said void on said die roughly overlays said mating metal pad on said substrate; and

15 (24) melting said wettable material, whereby each of said metal pads on said die is brought into fine alignment with said mating metal pad on said substrate via surface tension of said wettable material.

17. The method of claim 1, wherein step (2) comprises reactive ion
20 etching.

18. The method of claim 1, wherein step (2) comprises depositing an etch mask over said etch-stop layer, said etch mask defining said active mesa and said fiducial.

5 19. The method of claim 17, further comprising the steps of, after step (2):

(25) disposing a photoresist over said fiducial;

(26) further etching said structure; and

(27) removing said etch mask and said photoresist to expose said
10 fiducial.

20. The method of claim 19, wherein step (26) comprises further etching said active mesa.

15 21. The method of claim 20, wherein said active mesa is defined at least partially by etched cavities surrounding said active mesa, said method further comprising the step of:

(28) disposing a blocking layer in the etched cavities defining said active mesa.

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22. The method of claim 21 wherein step (3) comprises at least disposing protective layers on said fiducial.

23. The method of claim 22, wherein step (3) comprises disposing a burying layer on said active mesa.

24. The method of claim 23, wherein said blocking layer is disposed
5 by MOCVD or LPE.

25. The method of claim 23, further comprising the steps of, prior to step (1):

(29) providing a buffer layer on said substrate;

10 (30) growing a first quaternary layer on said buffer layer; and

(31) growing a cladding layer on said first quaternary layer,

wherein said layers created in steps (29)-(30) comprise said multilayer structure.

15 26. The method of claim 25 wherein step (1) comprises growing a second quaternary layer on said cladding layer, said second quaternary layer being said etch-stop layer.

27. The product of the process of claim 1.

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28. The product of the process of claim 26.

29. The product of the process of claim 11.

30. The product of the process of claim 12.
31. The product of the process of claim 14.
- 5 32. The product of the process of claim 15.
33. The product of the process of claim 16.
34. The method of claim 1, further comprising disposing a blocking
10 layer between said central mesa and said side mesa.
35. The method of claim 1, wherein said protective layer comprises
blocking material.
- 15 36. The method of claim 34, wherein said growing step comprises
disposing a burying layer on a top surface of said etch-stop layer of said central
mesa and on a top surface of said protective layer.
37. The method of claim 34, wherein said disposing of said blocking
20 layer is by MOCVD.
38. The method of claim 34, wherein said disposing of said blocking
layer is by LPE.

39. The method of claim 1, wherein said disposing of said protective layer is by MOCVD.

40. The method of claim 1, wherein said disposing of said protective
5 layer is by LPE.

41. A method for fabricating a buried heterostructure edge-emitting laser with a fiducial from a multi-layered structure comprising a substrate and an etch-stop layer, said method comprising the steps of:

- 10 (1) creating a multi-layered structure on a substrate;
- (2) growing a first quaternary layer on said multi-layered structure, said quaternary layer being an etch-stop layer;
- (3) etching through said etch-stop layer, cladding layer, first quaternary layer, and buffer layer to form an active mesa and a fiducial, said fiducial
15 comprising at least one surface positioned in a known spatial relation relative to said mesa;
- (4) disposing a photoresist over said fiducial;
- (5) further etching said active mesa; and
- (6) removing said etch mask and said photoresist to expose said fiducial
20 and define etched cavities surrounding said active mesa;
- (7) disposing a first blocking layer in the etched cavities defining said active mesa and a second blocking layer over said fiducial;

(8) disposing a burying layer over said active mesa, said blocking layer, and said fiducial; and

(9) selectively etching said burying layer and said second blocking layer to expose said fiducial.

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42. The method of claim 41 wherein step (1) comprises the steps of:

(1.1) providing a buffer layer on said substrate;

(1.2) growing a second quaternary layer on said buffer layer; and

(1.3) growing a cladding layer on said second quaternary layer;

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43. The method of claim 42, wherein said blocking layer is disposed by MOCVD or LPE.

44. The method of claim 43, wherein step (3) comprises reactive ion
15 etching.

45. The method of claim 43, wherein step (3) comprises depositing an etch mask over said etch-stop layer, said etch mask defining said active mesa and said fiducial.

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46. The method of claim 43 wherein said fiducial is a visual fiducial comprising a void in said multilayer structure.

47. The method of claim 46 further comprising the step of:

(10) placing wettable material in said voids on said die.

48. The method of claim 47 wherein step (10) comprises forming

5 metal pads in said apertures and subsequently placing said wettable material on said metal pads in said voids.

49. The method of claim 46 further comprising the step of:

(11) forming metal pads in said voids on said die.

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50. A method of mounting a die fabricated as set forth in claim 47 to a substrate having metal pads positioned to mate with said voids on said die, said method further comprising the steps of:

(12) placing said die on said substrate such that each said void on said
15 die roughly overlays said mating metal pad on said substrate; and

(13) melting said wettable material, whereby each of said metal pads on said die are brought into fine alignment with said mating metal pad on said substrate via surface tension of said wettable material.

20 51. A method of mounting a die fabricated as set forth in claim 49 to a substrate having metal pads positioned to mate with said voids on said die, said method further comprising the steps of:

(14) placing a wettable material on one of said pads on said substrate and said pads on said die;

(15) placing said die on said substrate such that each said void on said die roughly overlays said mating metal pad on said substrate; and

5 (16) melting said wettable material, whereby each of said metal pads on said die are brought into fine alignment with said mating metal pad on said substrate via surface tension of said wettable material.